
STRATEGIC PLAN FOR KNOWLEDGE MANAGEMENT

NASA Knowledge Management Team

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Table of Contents

<i>Foreword</i>	<i>1</i>
<i>Executive Summary</i>	<i>3</i>
<i>Vision</i>	<i>5</i>
<i>Mission</i>	<i>8</i>
<i>Goals</i>	<i>10</i>
<i>Background Information</i>	<i>144</i>
People.....	14
Process.....	166
Technology.....	188
<i>Summary</i>	<i>20</i>
<i>Appendix A. Charter</i>	<i>22</i>
<i>Appendix B. Guiding Documents</i>	<i>24</i>
<i>Appendix C. Examples of Knowledge Management As An Enabler</i>	<i>25</i>

FOREWORD

In the days when the vast array of NASA's resources was focused on a few long-duration programs (Apollo, Viking, Shuttle), we had the luxury of people sharing knowledge throughout the program. Engineers and scientists spent years, sometimes decades, working on a project, learning from the senior members and eventually mentoring junior team members. As an Agency, our knowledge base and abilities continued to grow. As we moved to a philosophy of applying the principles of faster-better-cheaper as appropriate, that era of apprenticeship and nurturing of the flow of experiential and tacit knowledge has become more fractured. In today's environment, engineers and scientists may work one to three years on a project and then move on. Individually they may gain a lot of knowledge, but that knowledge remains with them and is not captured or passed on broadly for future missions. New employees are tossed into a maelstrom of project implementation and expected to perform without any substantial introduction to NASA's processes, history, culture, and lessons learned. Rather than advocating a return to days of large projects, knowledge management principles offers a solution for moving ahead, acknowledging today's constraints and adapting to a world where technology and innovative processes must partially replace the mentoring and measured approaches of the past.

NASA's knowledge, its intellectual capital, is the Agency's primary, sustainable source of competitive advantage. Physical assets age, today's workforce is mobile, and technology is quickly bypassed. Our knowledge as an Agency, however, can endure. This knowledge is a fluid mix of experience and know-how that allows NASA employees to strive for and achieve the improbable day after day.

Those companies whose cultures promote knowledge sharing and individual learning have high employee retention, attract high-quality employees, and have a workforce that focuses on fixing the problem rather than fixing the blame.

Knowledge management is the spark that will ignite our ability to get the most from the investments we have made in our workforce and information technology, and to harness the considerable intellectual capital within the Agency and its partners. Implementations in KM are more than technology thrusts, but will build upon technology and information to help guide NASA through the intricacies of working with international teams and making ever-more-complex decisions. We have many of the key ingredients to making knowledge management succeed—a highly intelligent workforce, a need to learn in order to succeed, and some solid, technical infrastructure.

The three key areas upon which we need to move forward to more effectively manage our knowledge are

- Capturing more of the critical knowledge NASA needs to safely conduct missions
- Enabling virtual teams to work collaboratively at peak efficiency

- Managing more effectively the information we have already captured

If we do not begin to manage our knowledge as an Agency, we will repeat our mistakes. Worse, we will be destined to never learn from our successes. The gauntlet thrown down before us is to either deliver our missions from silo'ed organizations...or to invest the time and money to fly safely and successfully today while leaving a unique and irreplaceable legacy for the future of NASA and the Nation.

*Jeanne Holm, Chair
NASA Knowledge Management Team*

EXECUTIVE SUMMARY

NASA's need to capture the key knowledge of its workforce and learn from its lessons is evident. The methods by which we accomplish this goal are highly variable. The Administration, outside agencies, and our own workforce are calling for NASA to infuse knowledge management practices into the daily work of the Agency.

What is "knowledge management"? *Knowledge management is getting the right information to the right people at the right time, and helping people create knowledge and share and **act** upon information in ways that will measurably improve the performance of NASA and its partners.* This means providing access to information at the time people need it to make the best decisions possible for mission safety and success. It means

- Providing an engineer the history of design decisions on previous projects
- Giving a project manager access to the best risk management practices and tools when he or she needs them
- Providing the time for a senior scientist to mentor a promising young star

Some of this can be accomplished through clever information technology solutions and improved access to NASA's already rich, explicit information. The larger part of this relates to capturing the tacit knowledge of our workforce and effecting cultural changes that will encourage people to share what they know.

In seeking the best way to achieve such a vision, the NASA Knowledge Management Team has set forth this *Strategic Plan*. This strategy is based on best practices in industry and is geared to specifically addressing the internal drivers for enhancing our ability to share knowledge among projects and with our partners. Individuals are not intentionally keeping key information from others, but rather NASA's culture and environment inadvertently discourages individuals and projects from sharing. The findings of the NASA Integrated Action Team (NIAT)¹ clearly pointed to an environment where increasing time and budget pressures broke down lines of communication and prevented people from internalizing and applying previous lessons. Changes have been and are being made to change this, and the application of knowledge management practices is a key change.²

¹ See the report at <http://www.nasaappl.com/resources/updates/NIAT.pdf>

² NIAT action item 17 relates to knowledge management and the application of lessons learned.

There are three goals where KM activities can help NASA's ability to deliver its missions

1. To sustain NASA's knowledge across missions and generations,
KM activities will identify and capture the information that exists across the Agency
2. To help people find, organize, and share the knowledge we already have,
KM implementations will help to efficiently manage the Agency's knowledge resources
3. To increase collaboration and to facilitate knowledge creation and sharing,
KM teams will develop techniques, tools, venues, and facilities to enable teams and communities to collaborate across the barriers of time and space

In realizing these goals, some of the specific near-term objectives should include capturing key employee knowledge, managing the information resources we already have, and creating ways for remote teams to work collaboratively. The knowledge management efforts are envisioned as a coordinating function that encompasses implementation responsibilities that might be necessary to "fill the gaps" that exist between organizations.

This *Plan* sets forth the roadmap to move to an environment that encourages knowledge sharing, preserves our organizational memory, and allows our employees to learn both individually and from each other.

VISION

NASA's mandate to deliver leaner, more demanding, and increasingly more complex missions has resulted in our dependency on creating multidisciplinary teams, building alliances with contractors, and quickly and dynamically linking to and learning from other Agency activities. However, NASA's current array of processes, resources, and infrastructure does not adequately support this environment. Consequently, program and project managers are frustrated in trying to quickly identify the right people for teams, take advantage of our rich pool of experience, rapidly and broadly share information across organizational boundaries, and fully understand the range of the Agency's people, processes, and technology resources.

Recent reports scrutinizing failures at the Agency, and the subsequent recommendations of the NASA Integrated Action Team (NIAT), point to a fundamental problem in the ability of the Agency to communicate vital information within teams and across organizational boundaries. This is reaching a critical turning point as more and more of our key personnel reach retirement age. Today, up to 40% of our scientists and engineers are eligible to retire, with the number increasing to 55% by 2006.

Increasingly, entities outside NASA are calling for us to infuse knowledge management principles into our day-to-day work. *The President's Management Agenda* notes under "Strategic Management of Human Capital" that

KM plays a vital role in driving a learning culture, encouraging knowledge sharing, and supporting better decision making.

Downsizing at NASA over the last decade through attrition and buyouts has resulted in an imbalance in NASA's skill mix.... Knowledge management systems are just one part of an effective strategy that will help generate, capture, and disseminate knowledge relevant to the organization's mission.³

The Office of Personnel Management's report⁴ echoes this in

NASA is focusing a great deal of attention toward revitalizing its current workforce, especially with the loss of critical skills during past downsizing efforts.... NASA is focusing on knowledge sharing as a means to keep the workforce informed of project managers' real-life experiences and latest industry trends.

Finally, in a recent report, the General Accounting Office noted problems with NASA's ability to share lessons across the Agency.⁵ In that report, GAO pointed out

³ *President's Management Agenda, Fiscal Year 2002*, p. 13, <http://www.whitehouse.gov/omb/budget/fy2002/mgmt.pdf>

⁴ Office of Personnel and Management.

⁵ *NASA: Better Mechanisms Needed for Sharing Lessons Learned*, GAO Report to the Subcommittee on Space and Aeronautics, Committee on Science, January 2002, p. 36, <http://www.gao.gov/new.items/d02195.pdf>

Successful industry and government organizations (develop)... strategic plans that provide a framework for how knowledge management practices will be implemented and by securing the management support and commitment need to bring these plans to fruition.

We know that it is more critical than ever to better capture, organize, store, and distribute Agency knowledge resources to help achieve our goals. This impetus to manage knowledge comes down to understanding and applying a simple concept:

People + Information = Action

- ▼ **People**—The *employees* of NASA and its partners, the public, the Government, and the technical community.
- ▼ **Information**—Specific *learnings* that can be communicated between people (verbally, in writing, or through a method or process).
- ▼ **Action**—A *decision* or task that measurably improves the performance of the Agency or its partners, another organization, or an individual.

When people are given access to the information and resources they need to complete a task, they can finish it more quickly and effectively. An engineer selecting a part for a sensor, a scientist analyzing data from an experiment, a manager selecting among various new technologies—all these actions are more likely to succeed if the people have access to pertinent information about what has worked before and who has made the same analyses. *Knowledge management applications are the key to helping bring the right information to the right people at the right time.*

Knowledge management (KM) principles enable organizations to capture, organize, analyze, share, and reuse both explicit and tacit knowledge to make better and faster decisions across geographic, functional, and team boundaries. *The cornerstones of NASA's KM system are people, processes, and technology—all three aspects are needed to capture and harness the knowledge within NASA.* The KM framework focuses on collecting and integrating sources of information to enhance the quality of the actions based upon that information and to facilitate creation of knowledge.

The scenario on the following page sets forth a near-term vision of how investments in KM activities can explicitly enhance the way we do business.

DEFINITION

KNOWLEDGE MANAGEMENT is getting the right information to the right people at the right time, and helping people create knowledge and share and act upon information in ways that will measurably improve the performance of NASA and its partners.

Imagine yourself in a future knowledge-enabled NASA...

You have a great idea for an Earth-orbiting satellite that will seek out and collect 10% of all on-orbit debris, chemically bonding it to the satellite, thereby making shuttle and Space Station operations safer and delivering a significant cost savings to the tracking operations at the Deep Space Network. You see an Announcement of Opportunity (AO) and decide to submit a proposal. You are aware of a group of folks you know would be good—from NASA Centers, potential industry partners, and researchers at universities abroad. At the kickoff videoconference for the AO, you were given access to the Program and Project Management portal, which gave you many of the capabilities you need to work with your team.

As you start meeting online, you realize you also need to involve a chemist. The portal links you to a directory of experts across NASA, you narrow your search to a chemist at Goddard who has recent experience on a flight instrument—you can read her publications and see the notes and webcast video clips from an international workshop she recently led. You give her a call to see if she's available and interested.

You want to send out some information to your team, so you go to the portal and establish a forum for ideas on the technology innovation and set up a robotic agent to search for articles and postings on chemical bonding. You really need to talk to your team face-to-face, so you schedule a desktop videoconference for your team and DSN and shuttle experts (you found the experts in the directory and can schedule across everyone's calendar), then you reserve a room and time for a working meeting at Langley for a follow up discussion. You see your team members putting up lots of ideas and many postings coming from the "knowbot" agent—it's like having extra people researching for you!

As the proposal effort proceeds, your team uses the portal to publish and retrieve ideas, working documents, and links to related information. (In the background, you know the system is marking certain documents for long-term archive, as well as ensuring you will be ISO and ITAR compliant.) At a critical design point, another knowbot in the system notifies you that a specific lesson learned on a previous project may be applicable given your current design parameters. You review the lesson and the decision tree and design trade-offs related to it, and realize that the flight environments are different, so you're probably okay. You note the lesson and its attendant data should be reviewed again at the Preliminary Design Review—you can include the author of the lesson at your review.

Congratulations! You win the proposal and you begin working on moving from your proposal concept to actual implementation. You already have a working environment that you are familiar with and that contains all your research and documentation. You can hit the ground running.

MISSION

Knowledge management—facilitating the sharing of knowledge—occurs when people have easy access to and use tools, processes, venues, and facilities provided to help them solve problems and achieve understanding. Given the highly distributed, “virtual” teams at the Agency today, the challenge before the NASA Knowledge Management Team is to bring together people and their expertise across barriers of time, space, and culture. KM activities can provide an environment in which knowledge sharing and learning lead to actions in support of the Agency’s goals (Figure 1). For example, building upon existing processes in developing NASA’s project (such as NPG 7120.5A), KM activities to capture design decisions as they occur and share those with current and future projects could help lead to a culture where sharing knowledge is part of the daily work.

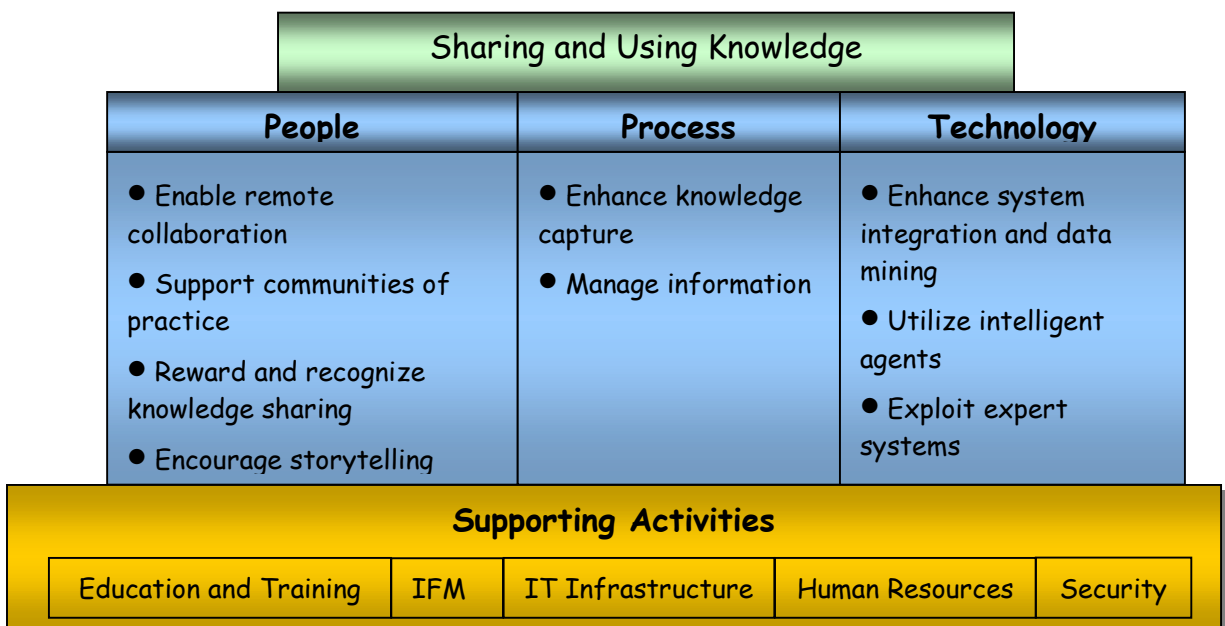


Figure 1. Knowledge management activities will build upon existing capabilities.

So are we attempting too much? No—others have succeeded in making such a cultural change. In looking at what others have done in the area of knowledge management, certain critical success factors were prevalent (Figure 2).⁶ In all cases,

⁶ Based upon research of case studies and benchmarking. *A Knowledge Management Architecture for JPL*, January 15, 1999.

organizations that succeeded in effectively managing their corporate knowledge did the following:

- ▼ Recognize and reward people for sharing knowledge
- ▼ Encourage and support communities of practice
- ▼ Strike a balance between long-term corporate needs (capturing knowledge) with short-term local needs (completing a task quickly)

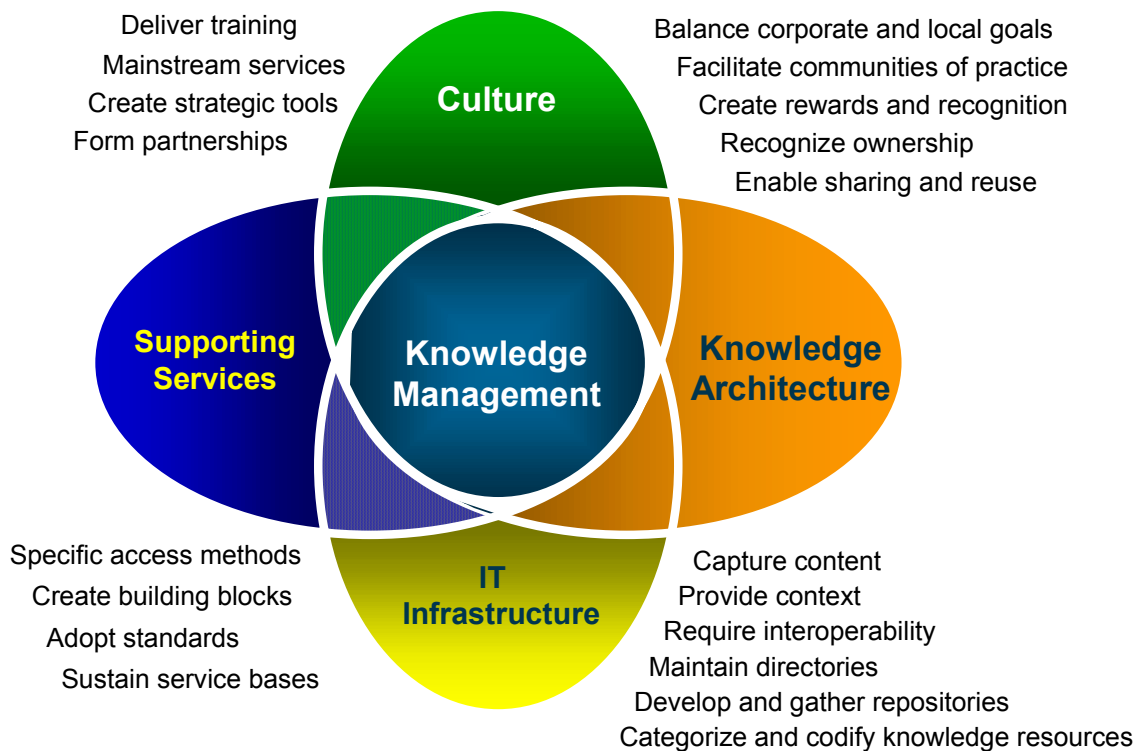


Figure 2. Critical success factors for knowledge management.

Some organizations have achieved success in knowledge management through a centralized KM organization, others through an architecture that unites distributed activities. A knowledge architecture that ties together many distributed activities fits in well with NASA's current structure and builds on the strengths of individual Enterprises and organizations efforts in knowledge management. In laying the groundwork for such an architecture, this *Strategic Plan* focuses on the key areas that need to be addressed and the themes under which an architecture can be constructed.

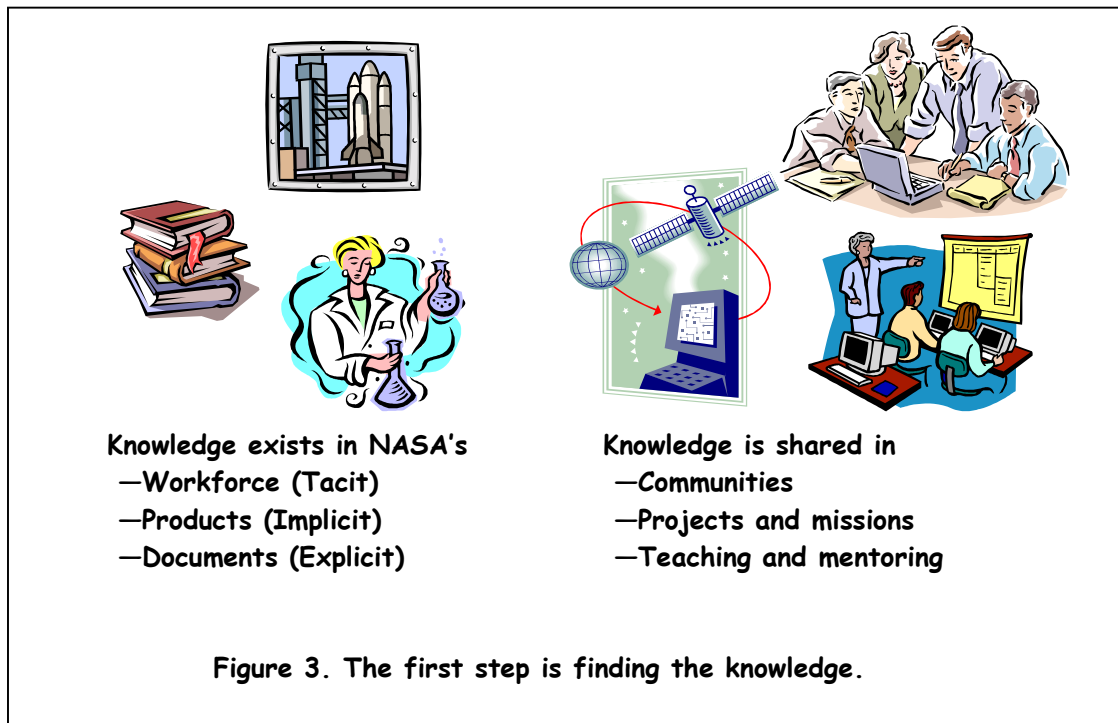
GOALS

To facilitate the initial implementation focus, we will need to invest in the infrastructure and may need to adjust existing Agency processes and procedures so that they support and encourage knowledge sharing across NASA. The strategies identified in this *Plan* for developing an integrated suite of KM activities are based upon requirements gathered from the Agency cross-cutting processes, as well as from other activities and organizations at NASA. The NASA Knowledge Management Team is committed to supporting the Agency's goals of enhancing mission safety and success, inspiring the human spirit, advancing and communicating scientific knowledge, furthering human exploration of space, and developing new technologies.

There are three priority areas where KM activities can help NASA's ability to deliver its missions:

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KM teams will develop techniques, tools, venues, and facilities to enable teams and communities to collaborate across the barriers of time and space

The customers of KM services will be scientists and engineers on NASA's missions and projects, program and project team members, Agency employees and contractors, and the public, including educators and policy makers. A key focus, based upon recent reports (such as *The President's Management Agenda*, GAO audit, and NIAT), is capturing the key knowledge of our workforce and broadly sharing that knowledge with the program and project management community (Figure 3). All NASA employees would benefit from having quick access to a vast and powerful array of resources to improve their effectiveness. The public would benefit from improved access to and products in education, technology, and science. A thoughtful approach to knowledge management can, in fact, provide an architecture and enabling services to many different groups within NASA and between NASA and its partners.



Moving from where we are today will be difficult—from scattered islands of information, distributed databases, and isolated experts—to where we must be—with tightly linked information resources and experts easily identifiable and accessible. While all of the changes will present challenges, some are straightforward and thus will be easier to achieve. These near-term milestones relate to enhancing existing processes or augmenting or adding technologies to better access and manage information. These changes can be brought about through judicious application of time and money.

The major areas for us to start working on (Figure 1) are encouraging and supporting *people* sharing information, enhancing the *processes* by which we capture and manage that information, and augmenting or building new *technology* to make this happen. Initial priorities relate to enhancing knowledge capture, managing information, and enabling remote collaboration for virtual communities.

KM thrusts:

- ▼ Capturing information
- ▼ Managing the knowledge at NASA
- ▼ Building tools for collaborative communities

OBJECTIVE

- To help move NASA to an organization where sharing knowledge across project and organizational boundaries is the norm and where the knowledge of NASA's workforce is available and infused into daily processes.

LONG-TERM GOALS (5-10 YEARS)

- To sustain NASA's knowledge across missions and generations
- To help people find, organize, and share the knowledge NASA already has
- To increase collaboration and to facilitate knowledge creation, sharing, and innovation

NEAR-TERM GOALS (1-5 YEARS)

1. Identify and capture the information that exists across the Agency
 - Encourage storytelling to share lessons learned
 - Enhance knowledge capture to sustain the knowledge of our workforce
 - Exploit expert systems for better decision making
2. Help to efficiently manage the Agency's knowledge resources
 - More efficiently and effectively manage the information we already have
 - Enhance system integration and data mining to pull together isolated knowledge bases
 - Utilize intelligent agents to deliver "just-in-time" information
3. Develop techniques and tools to enable remote teams to collaborate
 - Enable remote collaboration through tools and team training
 - Support communities of practice through electronic and traditional processes

In addition to an architecture unifying existing activities and identifying gaps, some of the near-term goals could result in processes or systems that "fill the gaps". As an example, three early knowledge management pilots are exploring and deploying solutions in partnership with other organizations. The work on these pilots was funded by the Chief Information Officer (Code AO) and conducted at the Jet Propulsion Laboratory, Langley Research Center, and Goddard Space Flight Center.

- ▼ Technical Standards Program (Code AE) and the program and project manager community sponsored by APPL (Code FT) will be early pilots of an Agency-wide portal. The portal is an electronic gateway that offers easy access to NASA's online resources through a personalized home page that collects the links, headlines, and business applications that are most relevant to the user. Some samples of commercial portals include MyNetscape and MyAOL. The

prototype portal is operational at a Center, with multi-Center participation underway (see <http://insidejpl.jpl.nasa.gov>).

- ▼ One of the early pilots implemented under the guidance of the NASA Knowledge Management Team was a redesign of the Lessons Learned Information System (LLIS) to better capture and infuse lessons learned into day-to-day activities on projects. The focus of the redesign was to deliver key information to a project member at the time they are making a critical decision.
- ▼ A pilot directory of experts was brought up to investigate the feasibility of automatically creating and updating profiles of Agency experts. With feeds directly from the Human Resources database, the experts' directory contains profiles of many people.

The following sections describe, in more detail, the issues that drive these goals. Examples of possible KM-related activities are shown for explanation, rather than as a set of specific near-term deliverables.

BACKGROUND INFORMATION

PEOPLE

People are the most critical factor in knowledge management. People create knowledge, share knowledge, learn, and use knowledge to complete the tasks of the Agency. KM activities will touch the people at NASA when they exchange information they *already* have and build on work they *are doing* to increase mission success. KM systems should be an enabler to the people, missions, and processes within the Agency, rather than an initiative that levies more requirements and work upon the projects.

The environment that will help move NASA to a knowledge-sharing culture has certain attributes. Primarily, the new environment is one that allows people to be recognized and rewarded for helping to share knowledge at the Agency level, rather than simply using their knowledge to complete a specific task on a single project. Some of the attributes of that new environment will be:

- ▼ Recognizing the value of both generalists (with their ability to offer cross-disciplinary insight and dialog between the experts of differing domains) as well as experts (with their ability to offer a depth of technical knowledge)
- ▼ Creating or augmenting position descriptions for people whose job is primarily to share or distribute knowledge
- ▼ Helping people to maintain and disseminate corporate knowledge through informal methods like networking and brown bags and formal methods like lectures by experts, subject-matter conferences, and communities of practice
- ▼ Nurturing an environment where sharing knowledge and working across organizational boundaries are seen as enhancing job security

Competency Management at KSC

Knowledge Management at the Kennedy Space Center takes on a human resources focus. A major project underway is developing a systematic method for understanding the competencies of the current skill base on the Center, and then developing a method to maintain, develop, or acquire high-priority competencies that are vital to the success of key strategic areas. The newly appointed "Knowledge Managers" in each organization are critical to making this happen.

KSC depends heavily on operational experience to build skills in the workforce (both craft and professional). Civil servants are moving out of daily operations and more experienced people are retiring. In the future, skills will be maintained using a different ratio of knowledge and experiences: less experience and more explicit knowledge and tacit knowledge transfer. KSC's KM program seeks to enhance the transfer of tacit knowledge to the future workforce through mentoring and networking. A key role of the Knowledge Manager at KSC is to manage gaps between current and future knowledge needs. This includes skill maintenance and growth, documenting competency types and levels, and organizational development planning (succession planning and training).

Knowledge sharing increases the ability of individuals to deal with new situations, events, information, and context. Many barriers to knowledge sharing crop up because the process relies heavily on human interactions and relationships that are not designed into NASA's current culture. NASA must create, promote, and foster a knowledge-sharing environment to replace the existing deep-seated culture to hoard information. Individuals must be developed and nurtured through strategic training and incentives.

Although formal program, project, and contract reviews are conducted, broad sharing of knowledge is not really an explicit NASA goal; rather it is the "fallout" resulting from a number of people participating in a community. A recognition of the importance of KM would promote these groups and help them prosper.

Implicit barriers to knowledge sharing currently exist within the Agency. These barriers are evidenced by the limited amounts of time and money allocated for knowledge-sharing activities. In addition, lack of resources aggravates the deep-seated tendency within NASA to hoard information, which, in turn, is implicitly reinforced when the Agency recognizes individuals and groups that do hoard. If research is proprietary, researchers are told not to share their ideas with anyone without a legitimate need to know. To succeed as an Agency, *all* our employees and partners need to share in the knowledge, not just the stars of the space program.

In addition, strong structural and legal mechanisms foster a culture of non-sharing. For example, the federal export-control requirements as contained in the International Traffic in Arms Regulations (ITAR) restrict sharing extensive categories of information with foreign nationals, even those working side by side with American citizens. Information deemed proprietary by contractors might not be released outside of NASA. All of these barriers need to be re-examined in the light of not only the desire to facilitate KM principles, but also of NASA's broad mission.

Very few if any rewards exist for sharing knowledge. There are methods, some in use by NASA and some by other organizations, which are likely to develop and nurture a sharing culture through appropriate training and incentives. Examples of these methods include

- ▼ Encouraging and ensuring reciprocity for ideas shared, particularly if the sharing evolves into new research or patents
- ▼ Including knowledge-sharing and/or mentoring goals as part of an employee's performance plan
- ▼ Preserving and distributing organizational knowledge
- ▼ Promoting career growth for those who have a history of helping others

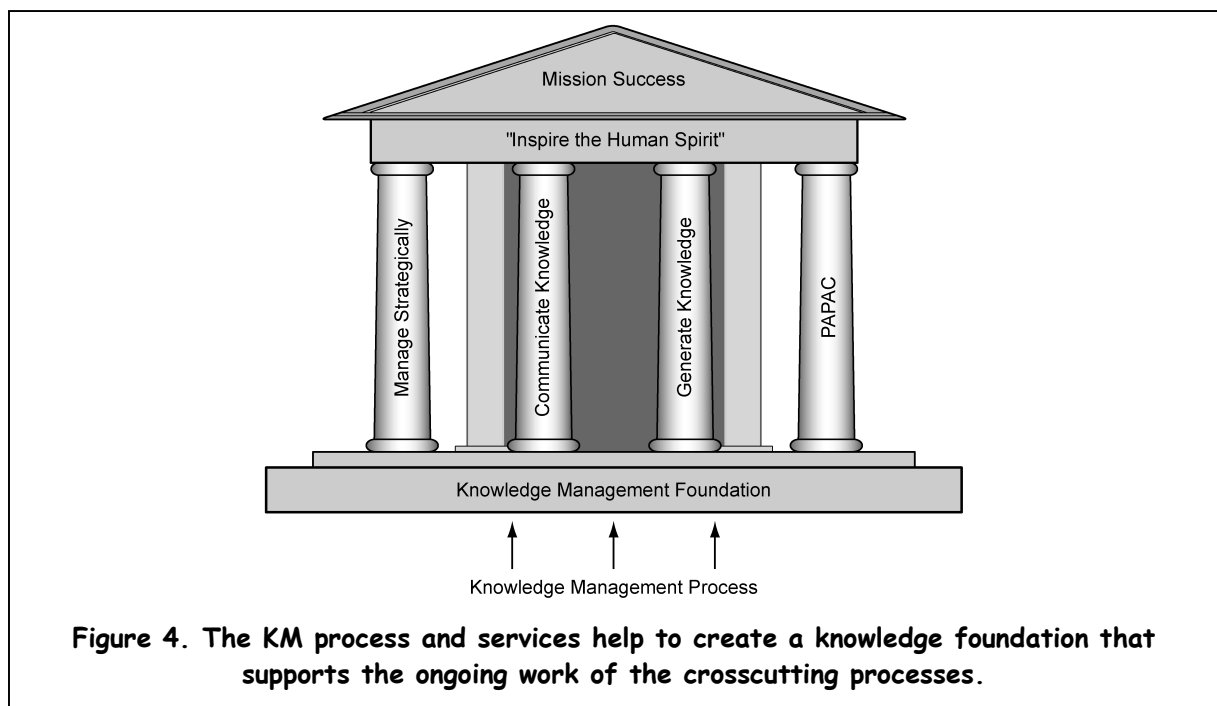
PROCESS

The process for managing knowledge resources is really a combination of the way in which people work and the lifecycle of information (remember that people + information = action). If we assume the processes for people's work at the Agency fall under the four cross-cutting processes (Figure 4), we still need to understand and define the lifecycle of information: How is information created, organized, stored, and distributed? What should be done with explicit information? How should it be made available to others? What should we do to capture the tacit knowledge in the minds of the knowledge workers at the Agency?

As we deliver more powerful knowledge-sharing capabilities to the NASA workforce, we must ensure that policies are published and understood for the appropriate use of such technology and far-reaching communications. Reiterating issues related to appropriate use of Government resources and sharing information across corporate and national boundaries is part of the KM process.

Knowledge management activities would be expected to deliver key functionality in support of the four Agency cross-cutting processes. For example

- ▼ The projects working under the *Provide Aerospace Products and Capabilities* (PAPAC) process will clearly benefit from a set of collaborative tools for virtual teams and communities to share information. Such a capability would need to incorporate into the tools the rules related to working with external partners.



- ▼ The *Generate Knowledge* process encourages and facilitates the creation, discovery, understanding, and publication of key scientific and engineering knowledge resulting from program and project implementation. It relies upon scientific and technical data, products and services from programs and projects, new technology, and outreach material. KM services can clearly help in capturing and managing that information as it moves from one level of maturity to another or as it moves from one researcher to another.
- ▼ The *Communicate Knowledge* process focuses on disseminating information broadly across internal and external audiences to increase the understanding of science and technology, advance its broad application, and inspire achievement and innovation. Communicate Knowledge requires a common set of services that KM systems can provide to NASA educators, projects, and scientists to manage and distribute their information.
- ▼ The *Manage Strategically* process looks at activities that provide both critical capabilities to our internal customers and external coordination with oversight and audit agencies of the Administration and Congress. The ability of our internal and external customers to gain easy access to information can clearly help in this area.

You Don't Have to Be a Rocket Scientist...

The Knowledge Management Program's Project Library system at JPL is used by 5000 customers around the world to help manage documents for flight projects. The new project manager of Mars '05 was meeting with the Project Library customer representative. She had a stack of papers three feet high—it included NPG 7120, ISO 9001, NPG 2810 on Information Technology Security, JPL's Policy on Document and Data Control, NARA Guidelines, and many, many others.

She told him, "You and all your project members need to be experts on every requirement in this stack, and then find, buy, and operate a system that lets you securely share information with your international partners. Oh, and there are overlaps and redundancies in many of these requirements. On the other hand, you can pay a small monthly fee for a Project Library, which we will operate for you. While it's your responsibility to make sure these requirements are met, using a Project Library will streamline meeting those requirements." The conversation continued, "Does it cover the archive requirements?" "Yes." "What about controlled records?" "It's in there."

After a handshake, a service agreement, and one week, the Mars '05 Project had an online, shared workspace, tailored for their specific partnerships and work breakdown structure. Built upon Xerox's DocuShare system, the structure supports ISO9000 through automatic creation of a Master Controlled Documents List. At the end of the mission, project documents will be moved to an online archive, incorporating requirements for records management, so that other projects will be able to learn from the Mars '05 successes.

TECHNOLOGY

Technology is one of many ingredients in delivering knowledge management solutions. Technology, in conjunction with human analysis, may offer the best large-scale method for providing the ability to capture, discover, communicate, transfer, and preserve knowledge. There are a variety of technologies available today, through commercial vendors, that can start to solve some of the specific issues related to knowledge management. Some of these technologies include:

- ▼ Web portals
- ▼ Non-intrusive data capture (such as simulation flight recorders)
- ▼ Expert system development and validation tools
- ▼ Data mining (looking for trends) and business intelligence

The use of such technologies can help us to create a KM system and methods that are more efficient and effective for people to use. In addition, such tools often allow us to gather metrics and to focus on creating repeatable, auditable processes to capture, communicate, and transfer knowledge. The goal in delivering technical solutions would be to utilize commercial-off-the-shelf products or build on existing capabilities whenever possible.

Some ways to measure outcomes include: workgroup productivity surveys, information metrics (files, records, and terabytes), cost avoidance calculations, and in the adoption of common tools, standards, and policies for information management. Part of the way NASA can move forward in implementing knowledge management is through the development, deployment, operation, and use of tools as illustrated in Table 1.

Managing Information at Marshall

The Virtual Research Center (VRC) is a web-based project-management information system. Tools within the VRC include a document manager, an action item tracker, a calendar, a team directory, a threaded discussion tool and an activity log. Each team using the VRC has a password protected area known as a wing. Potential team members apply for a badge by filling out an online form. Team leaders can approve membership with the click of a button and the VRC automatically generates an account for the new team member.

Since opening its virtual doors in 1997, the VRC user community has grown to more than 3300 registered users on over 175 project teams. Today, close to 15,000 files are stored in VRC team libraries. Over the past three years, the VRC development team has refined the interface and added functions based on comments from the user community. One example of an implemented suggestion is the team directory, which is automatically populated with data from approved badge request forms.

Current development efforts include incorporating object-oriented software technologies. With an object-oriented architecture, the VRC will serve as an environment for both knowledge management and collaborative engineering. Tools within the VRC, such as a threaded discussion tool, provide the capability for teams to describe experiences and thought processes. A search engine provides the capability to search through 75 different file formats for keywords. As legacy codes become integrated with the system, the VRC will automatically capture metadata associated with design analysis.

Table 1. Looking ahead with KM technologies to support change at NASA.

FOCUS	TODAY	TOMORROW
Knowledge capture	<ul style="list-style-type: none"> ▼ Poorly organized and missing knowledge ▼ No common process for knowledge capture and recapture ▼ Random publishing of technical memoranda ▼ Inconsistent use of the Lessons Learned Information System (LLIS) ▼ Irretrievable loss of Agency knowledge ▼ Relatively unknown Agency-wide “filing scheme” (i.e., taxonomy and metadata) ▼ Lack of adoption of data standards 	<ul style="list-style-type: none"> ▼ Organized and complete knowledge ▼ Standardized approach to capturing knowledge ▼ Knowledge engineers interviewing domain experts ▼ Graphically depicted processes and tools in information models (computer-aided systems engineering [CASE] tool) ▼ An Agency-wide filing system, including content guides, data access control, and indexing scheme ▼ A workforce that understands these processes and tools
Communication among distributed teams	<ul style="list-style-type: none"> ▼ Confusion about which tools to use ▼ Teleconferences ▼ E-mail ▼ Travel ▼ Sporadic use of videoconferencing and electronic white boards 	<ul style="list-style-type: none"> ▼ Ubiquitous tool kit ▼ Reduced travel due to sophisticated multimedia tools for teleconferences ▼ Extensive use of document management and asynchronous collaboration tools ▼ A culture that is comfortable with these tools
Knowledge preservation	<ul style="list-style-type: none"> ▼ Inability to open old electronic files because of changing technology ▼ No Agency-wide approach to handling media and format obsolescence ▼ Inconsistent and incomplete backup policies ▼ Sporadic use of tools for migrating data to new technologies 	<ul style="list-style-type: none"> ▼ Preservation and accessibility of important data ▼ Common policies for preserving data ▼ Institutional tools and plans for migrating data to new technologies

SUMMARY

The compelling need for better ways of sharing and using knowledge arises from the needs of the projects, programs, and communities in NASA. The drive toward shorter development times, quicker infusion, and innovative practices has forced projects to “hit the ground running”. In order to do this, all the infrastructure, processes, and information environment need to be easily adaptable and quickly applied to those new teams that need it. If KM is done correctly, the use of such processes and tools also helps NASA comply with the regulatorily alphabet soup requirements of ISO, GPEA, ITAR, EAR, and others. Taking the burden of day-to-day compliance of these off the shoulders of the projects would be a key delivery of a good knowledge management activity at NASA.

The more difficult—and in the end more critical—challenge lies in embracing knowledge-sharing in a way that preserves NASA’s innovative spirit, effectively manages constraints, and stays focused on the greater goals of the Agency while meeting tight mission deadlines. Today’s environment is one of tightly focused, task-specific missions that inhibit sharing between Centers due to competition. Tomorrow’s NASA must become one where tasks are interwoven to encourage knowledge sharing to achieve our goals. In this area, the essential changes are cultural—modifying how we reward people for sharing information, taking the time to make information reusable for others, and adapting or adopting previous best practices.

This will be a difficult change for NASA because we have prided ourselves on individual innovation and focused projects dedicated to a specific mission. We advocate global, “big picture” thinking, but reward local solutions. Because such cultural change does not occur quickly, we cannot achieve success singly, by Enterprise, Center, or initiative. Resolve and leadership must flow down from the highest levels for us to become an organization that shares knowledge broadly to achieve our greater goals.

The good news is that many areas within the Agency have already initiated local KM efforts. For example, education and training programs, collaborative tools, mentoring programs, document management systems, and online communities already exist, but in most cases, in isolation at Centers or within specific programs. KM activities will build upon and bridge the existing capabilities and resources to deliver an integrated suite of processes and tools to help share information across the Agency. Knowledge management is the next stage in identifying and capturing the Agency’s information, bringing together disparate resources, building the framework and providing the “glue” to enable integrated access, and delivering that information and capability to employees, missions, and partners. Since projects and missions focus on specific tasks, **it falls to the Agency’s knowledge management activities to**

Knowledge is of two kinds.
We know a subject ourselves, or we know
where we can find information upon it.

—Samuel Johnson

look beyond single endeavors and focus on the long-term: to invest in building the capabilities to share and manage knowledge over many projects and initiatives.

APPENDIX A. CHARTER

RESPONSIBLE OFFICE: AO/Chief Information Officer

SUBJECT: NASA Knowledge Management Team Charter

PURPOSE

This charter establishes the NASA Knowledge Management Team and sets forth its functions, membership, meetings, duration, and records disposition. Today's successful organizations are those that are explicitly building environments for creating and using knowledge to their competitive advantage. NASA's ability to generate and communicate our research and its results is central to achieving our mission. Rapid advances in information technology offer unprecedented opportunities to improve the way we capture, organize, distribute, and access NASA's knowledge base.

APPLICABILITY AND SCOPE

This charter is applicable to NASA Headquarters and NASA Centers, including Component Facilities, and to the Jet Propulsion Laboratory where specified by contract.

AUTHORITY

42 U.S.C. 2473 (C)(1), Section 203 (C)(1) of the National Aeronautics and Space Act of 1958, as amended; P.L.104-106, the Clinger-Cohen Act of 1996; NPG 1000.2, *NASA Strategic Management Handbook*; and NPD 1000.1, *NASA Strategic Plan*.

FUNCTIONS

The NASA Knowledge Management (KM) Team shall serve as an advisor to the NASA Chief Information Officer to:

1. Define knowledge management within the NASA environment
2. Identify NASA's current implementation of KM processes, policies, tools, capabilities, structures, and resources
3. Assess the state of the art in the knowledge management discipline
4. Gather requirements for KM design and implementation from key stakeholders

5. Define opportunities for applying KM to solve near-term challenges and identify ways to facilitate the transfer of best practices at NASA
6. Develop a strategic plan for meeting long-term Agencywide KM requirements

MEMBERSHIP

The membership of the Team shall include representatives from NASA Headquarters, the NASA Centers, and the Jet Propulsion Laboratory. The chairperson will be chosen, by the Chief Information Officer, from among these representatives. The NASA CIO may invite additional attendees to participate in Team meetings.

MEETINGS

Meetings will be held biweekly via electronic meeting capability (tele-, data-, or videoconference). In addition to these meetings, face-to-face meetings of the Team will be held occasionally.

DURATION

The NASA Knowledge Management Team will remain in existence until 2 years from the effective date of this Charter, whereupon it may be renewed on an annual basis.

RECORDS

The chairperson, appointed by the NASA CIO, will be responsible for the maintenance of this Charter and all other records associated with the NASA Knowledge Management Team.

APPENDIX B. GUIDING DOCUMENTS

NPG 7120.5B	<i>NASA Program and Project Management Processes and Requirements</i>
NPD 2800	<i>Managing Information Technology</i>
NPD 1000.1	<i>Strategic Plan</i>
NPG 1000.2	<i>Strategic Management Handbook</i>
NPD 8700.1	<i>NASA Policy for Safety and Mission Success</i>
40 U.S.C. 1401	<i>Clinger-Cohen Act of 1996</i>
42 U.S.C. 2473	(C)(1), Section 203 (C)(1) of the National Aeronautics and Space Act of 1958, as amended
	<i>Federal CIO Council Strategic Plan, Fiscal Year 2001-2002</i>
	<i>Blair House Paper, 1997</i>
Public Law 104-106	Clinger-Cohen Act of 1996

APPENDIX C. EXAMPLES OF KNOWLEDGE MANAGEMENT AS AN ENABLER

INTEGRATED FINANCIAL MANAGEMENT

IFM and the NASA KM Team see their first goal as similar—“provide timely, consistent, and reliable information for management decisions”⁷ IFM focuses on delivering financial information, while KM activities extend that to include engineering, science, programmatic, project, and other contextual and technical information. Of IFM’s other four main goals, knowledge management directly enables two more—to achieve efficiencies and operational effectiveness, and to exchange information with customers and stakeholders. KM will build upon the technologies and functionalities planned for IFM to deliver a more powerful set of combined resources for Agency decision makers.

OFFICE OF THE CHIEF ENGINEER

Some of the key goals for the Office of the Chief Engineer (OCE) include those upon which KM activities are reliant or aligned, such as:

- Capture and disseminate best practices in system engineering
- Guide development of broadly applicable standards and interoperable tools to enable an advanced engineering environment
- Provide cross-enterprise products and services that enable infusion of technology, knowledge, and capabilities to support innovation in engineering and push the state of the art
- Improve the PAPAC process by evaluating, piloting, and implementing across the Agency new tools for program and project managers; and working with the Program Management Council Working Group (PMCWG)

e NASA

As a more in-depth example of how KM activities will support current and new activities at the Agency, we can look at one activity under development by Code AO. The eNASA framework looks at how the Agency will electronically enable government-to-business and government-to-citizen transactions and deliver services and information to NASA teams, employees, partners, and the public. The team’s stated goal is to “enhance mission success through seamless, community-focused electronic service delivery.” Such a goal will be accomplished by building upon existing

⁷ IFM Program, “Agency Business Drivers,” May 22, 2000.

or soon-to-be-deployed services, such as knowledge management services, collaborative tools, web services, e-learning advances, IFM, and the existing IT infrastructure. The NASA KM Team plans to support this activity by enhancing and deploying an infrastructure for people to share knowledge across communities. As with IFM, eNASA and KM goals are aligned to create a leadership environment that fosters desired cultural change, strategically invest in critical infrastructure and competencies, and optimize a shared services model for projects and missions.

The NASA KM Team will accomplish this through deployment of portals (customizable web sites that provide targeted information to people and allows them to publish to specific communities), support of e-learning technologies, enhanced capture and distribution of lessons learned, support for the development and growth of communities of practice, and creation of collaborative environments to enable sharing and managing of the knowledge developed within a community. Specifically, KM activities could do the following:

PORTALS⁸

- ▼ Provide a scalable hosting infrastructure design
- ▼ Provide a “cookbook” for preparing project and organization elements (building blocks) for integration into a portal environment, including information publishers and users
- ▼ Provide a portal team framework

E-LEARNING

- ▼ Bring an online learning environment and distributed learning tools to the content, guideline, and leadership of Code FT’s e-learning vision to
 - ▼ Bring appropriate APPL classes to the desktop
 - ▼ Facilitate the creation of “miniclasses” by NASA experts through simple support materials and enabling technology for creating accessible and/or computer-based training

LESSONS LEARNED²

- ▼ Push “positive” lessons learned to the desktop, based upon project, task, or organizational characteristics
- ▼ Provide a subscription service for specific lessons learned tailored to user-defined interests

⁸ These activities are extensions of recent work by the NASA KM Team. Code AO funded these activities as pilots in FY’00.

- ▼ Ensure that human analysis remains part of the process for lessons learned (realizing that, for example, Mars missions can learn from the Apollo Moon landings in relation to sample return issues and contamination)

COMMUNITIES OF PRACTICE

- ▼ Facilitate communities of practice through Agency-wide awareness and education efforts
- ▼ Solicit existing communities for requirements
- ▼ Provide accessible infrastructure support via the desktop
- ▼ Gather success stories from communities (informal metrics)
- ▼ Look at tiger teams and other teams that function outside the usual structural constraints to determine what the success factors are for such groups

COLLABORATIVE ENVIRONMENT

- ▼ Build upon previous surveys of best practices and criteria for an operational environment
- ▼ Establish a first-generation collaborative environment for a virtual team that would include partners, investigators, and key vendors

The development of such tools and support of processes would be reusable across many different activities.